

Draft MLK Corridor Rail Crossing Safety Review Technical Memorandum

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Revision History

Version	Title	Date	Notes, As Required
0	Draft	10/29/21	

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Appendix A	ST Rail Collisions, Near-misses, and Close Calls
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Acronyms

IIRPM	Internally Illuminated Raised Pavement Markings
LEDs	light emitting diodes
MLK	Martin Luther King Jr. Way South
MUTCD	Manual for Uniform Traffic Control Devices

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1 INTRODUCTION

1.1 Overview

This memorandum (memo) provides a rail safety review of the Sound Transit Link Light Rail line that runs at grade on Martin Luther King Jr Way South (MLK). This review is focused on rail safety on MLK between South Dakota St and South Henderson St. which has experienced a higher than expected rate of collisions, near misses and close calls between vehicles, pedestrians and bicycles, and light rail trains.

The safety review focuses on three areas of rail-highway safety to achieve reductions in accidents and incidents at rail-highway intersections to include: engineering, enforcement, and education. All three of these areas should be focused on the MLK corridor to reduce accidents with vehicles and pedestrians.

1.2 Purpose of report

This memo summarizes vehicle, bicycle and pedestrian collisions, near-miss and close calls with Sound Transit Link Light Rail trains and provides recommendations on potential mitigation measures to reduce the rate of rail accident/incidents in the corridor. The recommendations listed in this memo were developed based on review of available data from Sound Transit between the years of 2009 and 2021, along with vehicle crash data from the City of Seattle between 2017 and 2021.

1.3 Study Area and Intersections

As shown in **Figure 1**, the study area includes Link Light Rail operations along MLK between South Henderson St. (on the south end) and South Dakota St (on the north end) including the following twenty intersections with MLK (all with a South prefix).

- Dakota St.
- Edmunds St.
- Orcas St.
- Willow St.
- Renton Ave./Webster St.
- Elmgrove St.
- Trenton St.
- Columbian Way/Oregon St.
- Dawson St.
- Graham St.
- Myrtle St.
- Holden St.
- Thistle St.
- Henderson St.
- Alaska St.
- Brandon St.
- Holly St.
- Othello St.
- Kenyon St.
- Coverdale St.

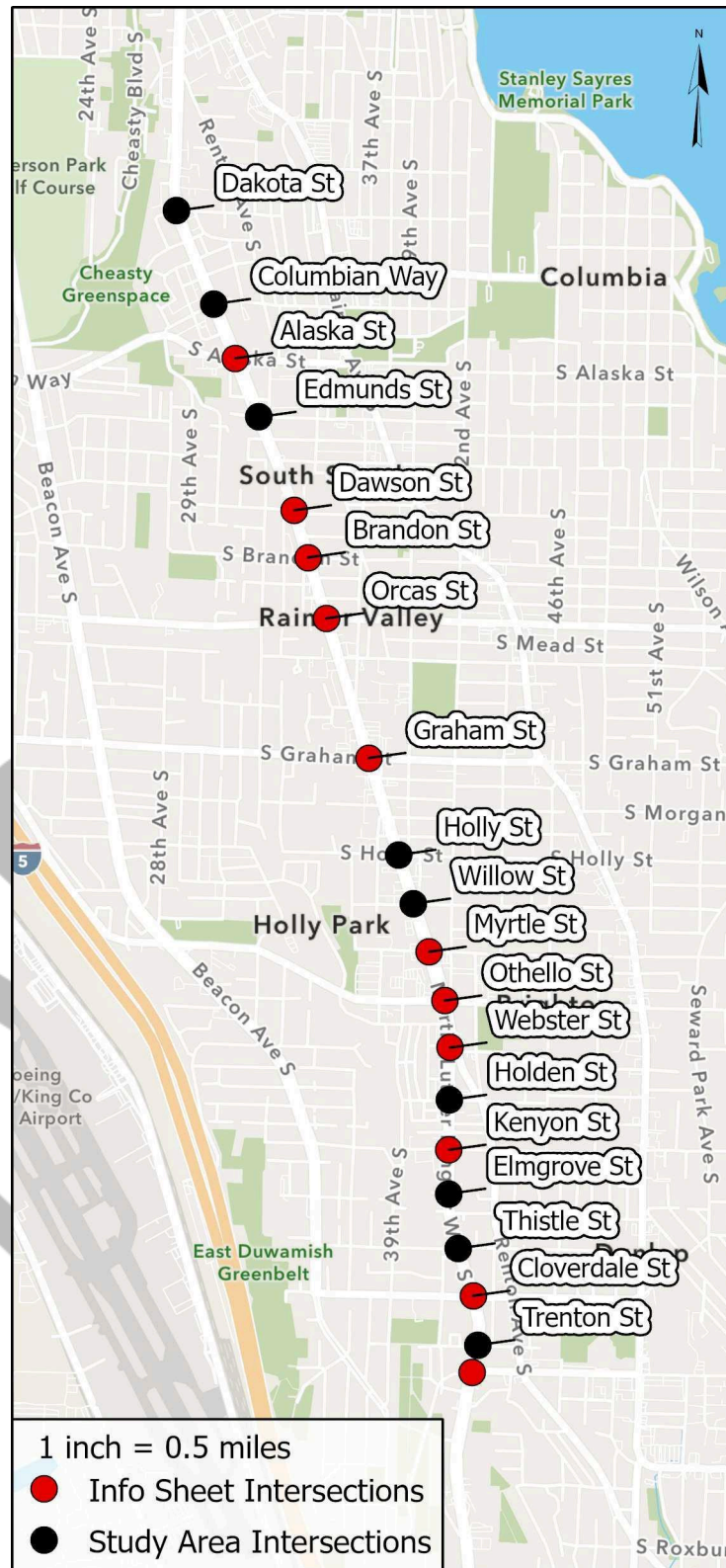


Figure 1: Study Area and Study Intersection

2 OPERATING ENVIRONMENT

The Link Light Rail alignment in the study area is at grade and center running through all 20 evaluated intersections, with a maximum operating speed of 35 mph. There are three stations in the study area at Edmunds St., Othello St. and Henderson St. Study intersections are signalized. MLK has two lanes in each direction with sidewalks and left turn pockets at most signalized intersections and a posted speed of 25 mph. All 20 study area intersections are signalized with pedestrian crossings. Bicycles are present but there are no dedicated bicycle facilities in the study area on MLK.

In the study area, Link Light Rail trains operate on a signalized signal system integrated with the City of Seattle intersection signals. The train signal system is designed to preempt the City intersections signal operations in cascading fashion to allow the train to proceed through the intersection without stopping between stations, which minimizes train delays from the intersection signals. Train departures from stations are coordinated with the City intersection signal system to coordinate train and signal operations to minimize the impact of the signal preemption on intersection operations. By the nature of this system, the impacts of transit signal preemption tend to be felt more as the train travels farther from each station, until the train stops at the next station and the system can coordinate the train departure from the station while the train dwells to load and unload riders.

In the study area, grade crossing gates are not used for vehicle, bicycle or pedestrian crossing of the tracks. At grade crossings, train approach warning signs are installed in conjunction with the intersection signals to alert automobile drivers of approaching trains. Grade crossings are also equipped with audible warning bells and flashing warning signs which activate when trains approach a grade crossing.

3 FINDINGS AND RECOMMENDATIONS

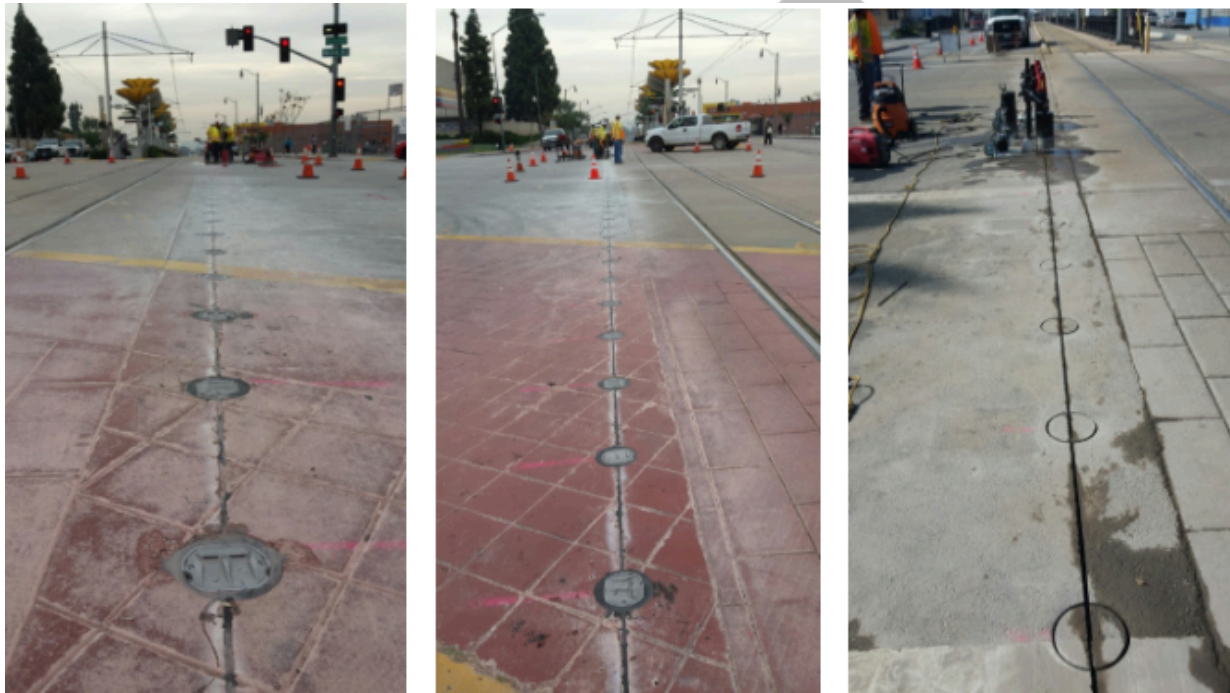
Rail-highway safety has focused on three key areas to achieve reductions in accidents and incidents at highway rail intersections: engineering, enforcement, and education. All three of these areas should be focused on within the MLK corridor to reduce accidents between light rail trains, vehicles and pedestrians.

3.1 Engineering

Building on the previous studies and recommendations that were developed in 2017, there are some additional engineering applications ST may wish to investigate further that may help reduce illegal left turns at these intersections. These countermeasures have been used in an experimental application in Southern California on Los Angeles Metro (LA Metro) light rail services. LA Metro has several light rail lines that operate in similar environments for portions of their right-of-way, with center boulevard arrangements, and left turns across the tracks.

3.1.1 Internally Illuminated Raised Pavement Markings

Internally Illuminated Raised Pavement Markings (IIRPM) use light emitting diodes (LEDs) connected to a controller and power source that illuminate red when a train is approaching and occupying a roadway intersection. The IIRPM's are installed into the roadway surface and protrude slightly above the surface. **Figure 2** shows the application and installation.



Photos courtesy of LA Metro

Figure 2. Internally Illuminated Raised Pavement Marking

Our research found that Houston Metro experimented with a IIRPM application back in 2010-2011 to see if it would reduce vehicles running red lights and colliding with light rail vehicles. The system was not robust and was subsequently shut off as it failed, and the vendor went out of business. Preliminary data did indicate some reduction in accidents; however, it was not statistically significant.

LA Metro began a research project looking at a similar product in 2012, with the goal of reducing illegal left turns into light rail vehicles at intersections. **Figure 3** shows the IIRPM in operation as a train enters the intersection. FHWA approved the experimental application for a 2-year test. The equipment was installed in 2015 on the Blue and Gold Lines. Unfortunately, there were some equipment issues which required the revision of the experiment to ensure reliable data and evaluation processes. The FHWA approved the test modifications and evaluation process in 2017. Data was collected for two months and analyzed by researchers at the Department of Civil and Environmental Engineering at California State University Fullerton. The research team concluded that:

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“In general, the results of the research showed that IIRPMs may significantly reduce the average number of left-hand turn violations. These findings were expected and consistent with prior research on the impact of IIRPMs and in-roadway lights which showed a clear pattern of encouraging drivers to comply with traffic control devices. However, data limitations prevented a more robust analysis of the hypothesis testing. Although the ON and OFF periods consisted of 34 days, outlier data and issues with the vehicle count equipment resulted in a limited data set. It is recommended that additional research be undertaken.”¹



Photo Courtesy of LA Metro

Figure 3: LA Metro light rail vehicle and IIRPM's

As Sound Transit's alignment along MLK is similar to these LA Metro intersections, ST may want to examine this technology further and perhaps conduct research.

¹ Parr, Murga, Sharma, California State University Fullerton, Reducing Left Turn Violations with Illuminated Raised Pavement Markers, 3/26/18 Draft Final Report

3.1.2 Dynamic Envelope Pavement Markings

The 2009 edition of the Manual for Uniform Traffic Control Devices (MUTCD)² Section 10C describes the usage of dynamic envelope pavement markings for light rail. **Figure 4** shows the typical application from the MUTCD.

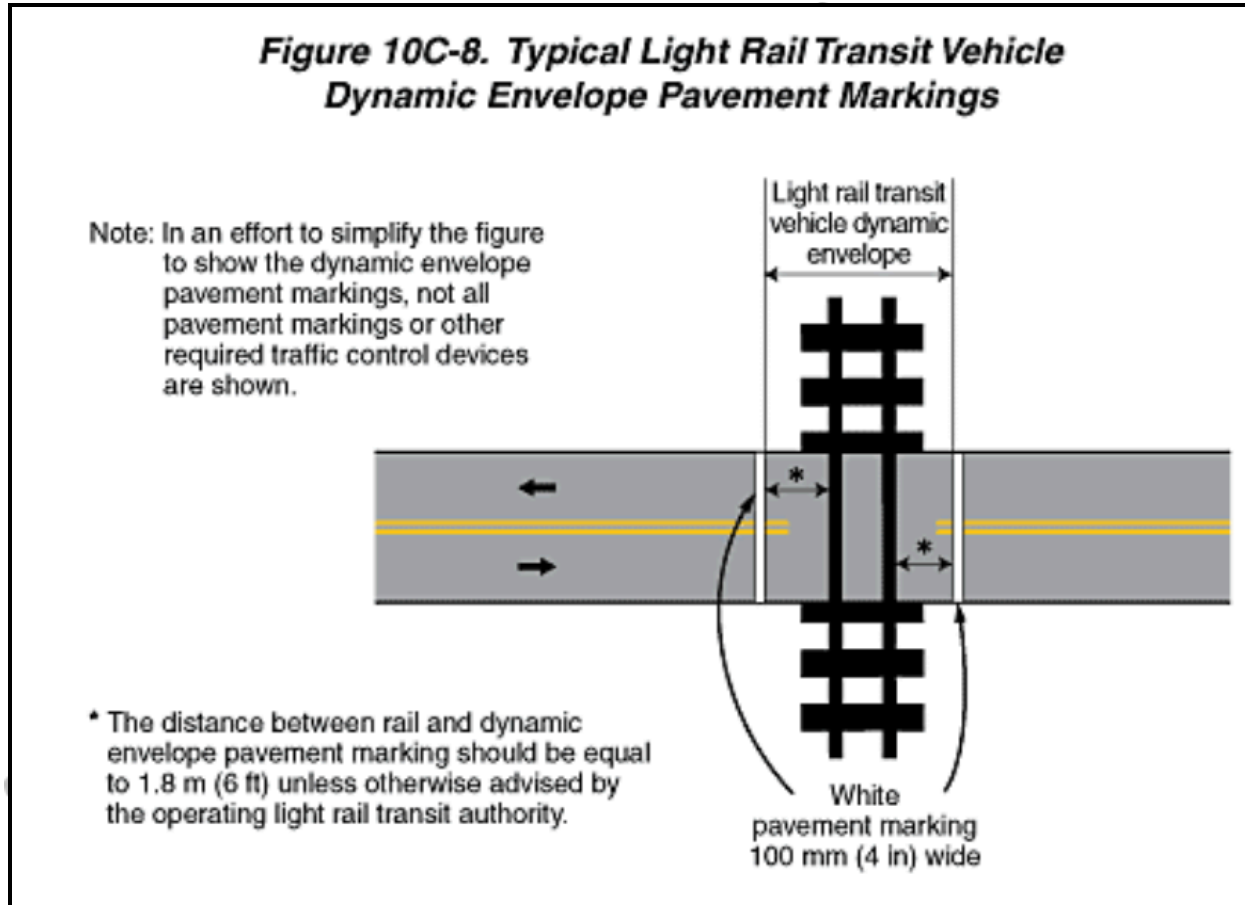


Figure 4: Dynamic Envelope Pavement Markings

The light rail/street crossings along MLK appear to originally have been constructed with a colored pavement material to distinguish the dynamic envelope from the surrounding street. However, over time, these markings have faded considerably, and the contrast is no longer as apparent. ST should consider having the dynamic envelope pavement markings reapplied at intersections along the MLK corridor.

3.1.3 Left Turn Lane Gate

LA Metro also conducted research on the use of a left-turn gate to prevent accidents on its Metro line. In 2017 on Flower Street between 18th and Cameron St. in Los Angeles, a left turn

² <https://mutcd.fhwa.dot.gov/>

gate was installed as part of a demonstration study to test the technology. The gate is similar to those used in parking garages and is a much smaller than a typical railroad crossing gate application. The gate arm is approximately 10 feet long, and only extends across the left turn lane. The gate mechanism is much smaller than a railroad gate, and there are no counterweights that extend behind the mechanism, so it can fit into a raise median. **Figure 5** shows the drawings of the gate. **Figure 6** shows a gate in operation.

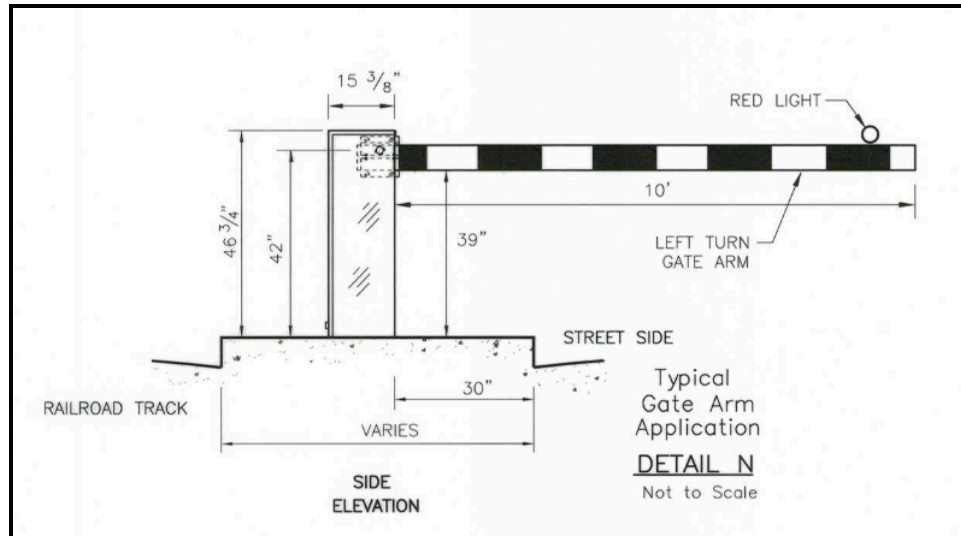


Figure 5: Left Turn Gate used by LA Metro

This demonstration project is being evaluated, and LA Metro is planning to install 6 more of these on the new Crenshaw Line that is being constructed. Future plans include expanding the project to the San Fernando Valley line. ST may wish to explore the feasibility of installing a similar gate to test the application along the MLK corridor.



Figure 6: LA Metro left turn gate

3.2 Enforcement

3.2.1 Photo Enforcement of Left Turn Violations

LA Metro has installed illegal left turn photo enforcement equipment at a number of intersections along its Gold, Orange, Expo, and Blue lines in conjunction with the Los Angeles County Sheriff's Department. **Figure 7** show an example in the field. The program is designed to help keep community members, transit riders, and drivers safe by deterring drivers from making illegal left turns. In our discussion with LA Metro, it has been an effective tool in combating illegal left turns.



Figure 7: LA Metro Photo Enforcement

The system is similar to the red light and school zone speeding ticket system used by the City of Seattle today. An image is taken of the vehicle and license plate and mailed to the vehicle owner, who then pays, or may contest the infraction. The Revised Code of Washington (RCW) does allow for use of photo enforcement systems for red light violations and railroad crossings. LA Metro is expanding this program to a new light rail line over the next several months. They have implemented a community outreach campaign in advance to introduce the system to the area and provide warnings to people during the initial phase. For more information go to the following link: https://www.metro.net/calendar/clax_photo_enforcement/

3.3 Education

The Link light rail line along MLK has helped foster a variety of changes to the area, as fast, frequent light rail service to other parts of Seattle are now possible. This has encouraged new transit-oriented development near the stations that includes new apartments, townhomes, and condos. In turn, this has led to an increase in pedestrian use to access transit and new commercial and residential facilities, especially near stations. In addition, as the light rail network expands, travelers to the area may not be familiar with the station and intersection designs, as most other sections of Link are in tunnels or viaducts. Therefore, it is important to have a targeted and focused safety outreach campaign along the corridor that focuses on safety around the tracks and at intersections. This program needs multiple channels to focus the message to different audiences.

In addition, ST may wish to consider establishing a safety ambassador program along the corridor, to have an in-person presence in at stations and intersections. These safety ambassadors could be on the lookout for people who take unnecessary risks at some crossings and remind them to be safe. Additionally, they could conduct safety outreach activities to schools, businesses, and local civic groups along the corridor.

4 CORRIDOR SAFETY SUMMARY

A review of the ST collisions, near misses and close calls between 2009 and 2021 found 10 intersections with more than 13 train events (one event per year on average). A total of 294 train events were found in the data at all 20 intersections, as shown in **Figure 8**.

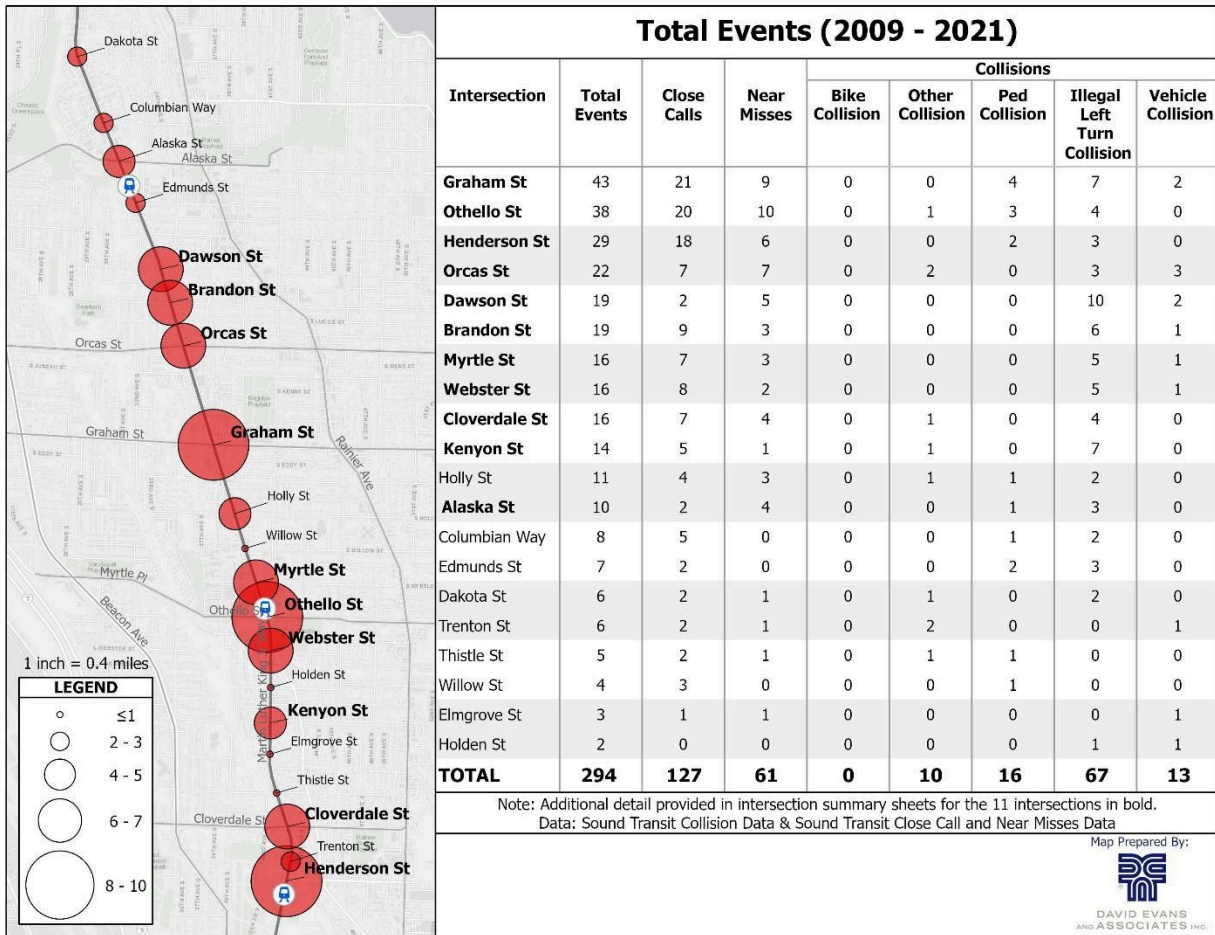


Figure 8: Total Rail Safety Events

The Graham intersection has the most total events at 43 and the most collision at 13, as shown in **Figure 9**. Othello St. had the most near-misses and close calls followed closely by Graham St.

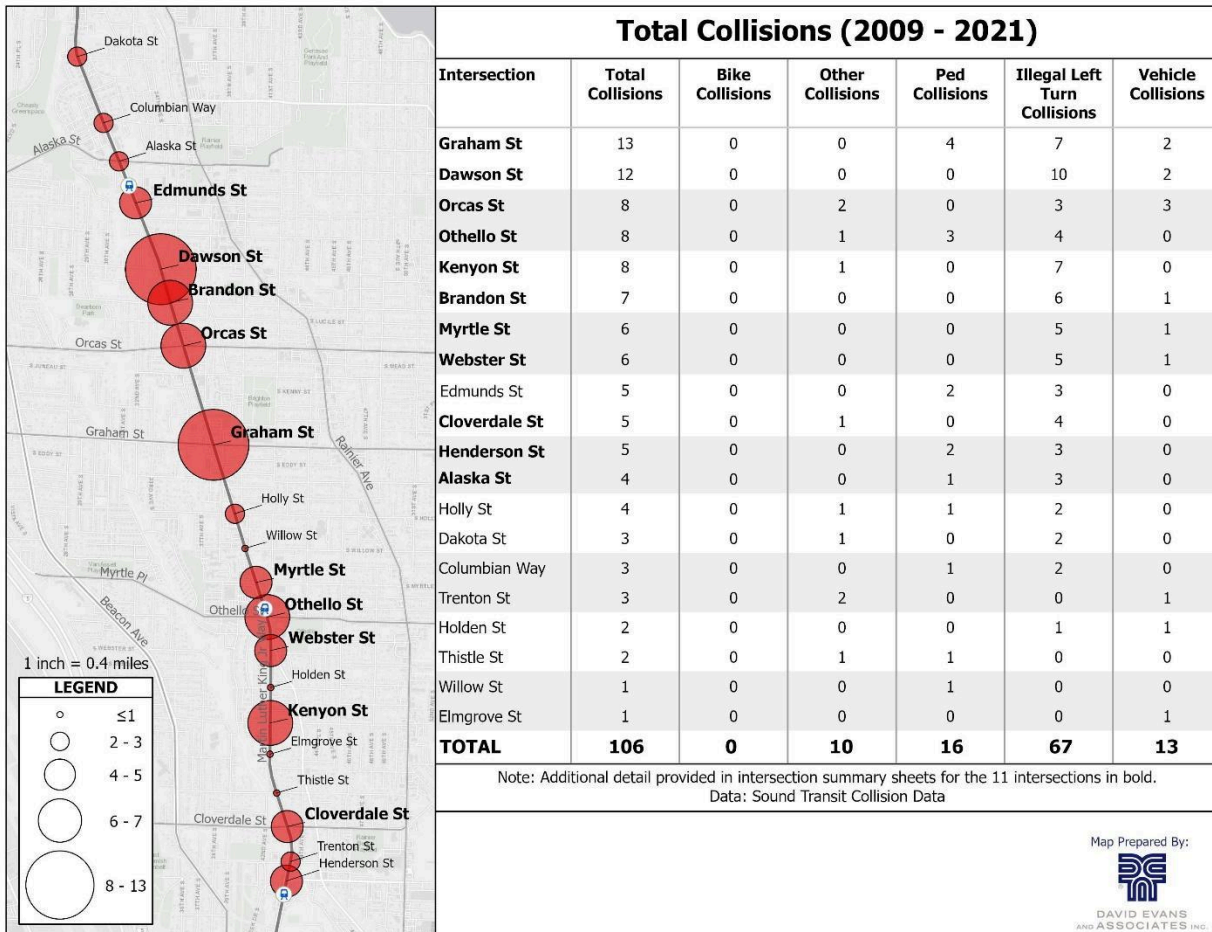


Figure 9: Total Rail Collision

The majority of total rail events are in the southern part of the corridor from Graham St. south. Collision with trains are occurring more evenly through the corridor with Dawson St. at the north end having the second highest number of collisions and Cloverdale and Henderson at the south end being in the top 10 (tied for 10th). Graham St. has the most pedestrian collisions and second most illegal left turn vehicle collisions with a train. Dawson St. has the most illegal left turn collisions with a train.

Additional breakdown of the ST light rail collisions, near misses and close calls are in Appendix A.

Review of City of Seattle crash data between 2017 and 2021 found a total of 276 crashes with the highest number of crashes occurring in 2019, shown in **Table 1**. Angle crashes are the most common as shown in **Table 2**.

Table 1: City of Seattle Reported Crashes by Year (2017-2021)

Total Crashes Per Intersection						
Street	2017	2018	2019	2020	2021	Total
OTHELLO ST	5	11	10	8	5	39
CLOVERDALE ST	6	5	8	3	7	29
GRAHAM ST	6	9	2	6	1	24
MYRTLE ST	5	7	5	4	3	24
HENDERSON ST	2	6	8	1	4	21
ORCAS ST	8	9		4		21
ALASKA ST	4	7	2	2	2	17
WEBSTER ST	2	6	4	3	2	17
KENYON ST	4	2	3	1	3	13
COLUMBIAN WAY	2	2	4		2	10
DAWSON ST	2	2	3	2	1	10
HOLLY ST	3	2		2	2	9
OREGON ST	1	1	3	1	2	8
BRANDON ST		3	3		1	7
DAKOTA ST	2	2	1	2		7
EDMUNDS ST	1	1		1	3	6
		1	3			4
TRENTON ST	1	1	1	1		4
THISTLE ST		2			1	3
WILLOW ST	1			1		2
HOLDEN ST				1		1
Total	55	79	60	43	39	276

Table 2: City of Seattle Reported Crashes by Type (2017-2021)

Total Crashes Per Intersection

Street	Angles	Cycles	Left Turn	Other*	Pedestrian	Rear Ended	Sideswipe	Total
OTHELLO ST	10	1	9	10	3	3	3	39
CLOVERDALE ST	13		11	3		2		29
GRAHAM ST	7			8	3	3	3	24
MYRTLE ST	6		7	5	3	3		24
HENDERSON ST	5	1	2	7	2	3	1	21
ORCAS ST	8		5	2	1	2	3	21
ALASKA ST	4	2	3	1	1	4	2	17
WEBSTER ST	9	1	3	2	1	1		17
KENYON ST	8			2	1	2		13
COLUMBIAN WAY	3		2	2	2	1		10
DAWSON ST	2		1	6	1			10
HOLLY ST	3		2	3		1		9
OREGON ST	1	1	2	2		1	1	8
BRANDON ST	1			3	1	2		7
DAKOTA ST	4		2		1			7
EDMUNDS ST		1		2	2	1		6
			3	1				4
TRENTON ST		1		3				4
THISTLE ST	1		1			1		3
WILLOW ST		1		1				2
HOLDEN ST					1			1
Total	85	9	53	63	23	30	13	276

* Other includes: <NULL>, Head On, Parked Car, and Right Turn Collisions

Othello has the greatest number of crashes at 39 with 9 of those being left turns. Cloverdale was second with 29 with 11 of those being left turn crashes and 13 designated as angle crashes. The City of Seattle crash data aligns with the ST light rail collision data in terms of the locations with higher events. As shown in **Figure 10**, left turn and angle crashes are the most common crash type. Most incidents result in property damage only or injuries that are not serious or fatal as shown in **Figure 11**.

Number of Crashes by Collision Type

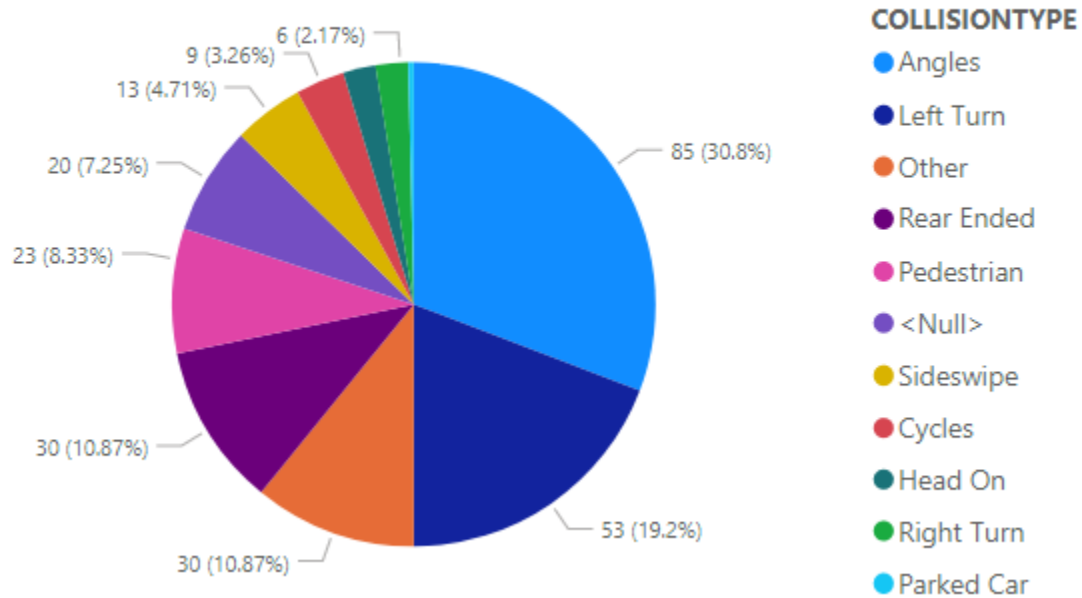


Figure 10: City of Seattle Reported Crashes by Type (2017-2021)

Number of Crashes by Severity Type

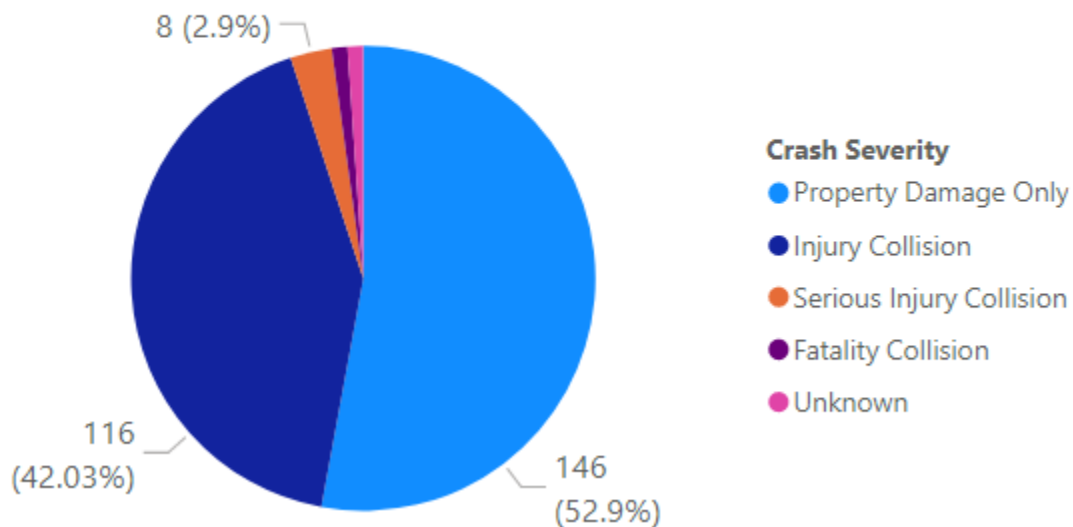


Figure 11: City of Seattle Reported Crashes by Severity (2017-2021)

5 INTERSECTION SAFETY REVIEW

Based on the corridor level review of total rail events and fatalities found in the ST data, the following eleven intersections were selection for more detailed review.

- Graham St.
- Othello St.
- Henderson St.
- Orcas St.
- Dawson St.
- Brandon St.
- Myrtle St.
- Webster St.
- Coverdale St.
- Kenyon St.
- Alaska St.

Summary sheets for the eleven intersections are provided in this section. They provide a summary table of train events at the intersection along with an aerial view showing where the collisions occurred. A list of intersection infrastructure is provided on the bottom left along with a summary of recommendations for the intersection and the field photos.

Crossing Safety Review

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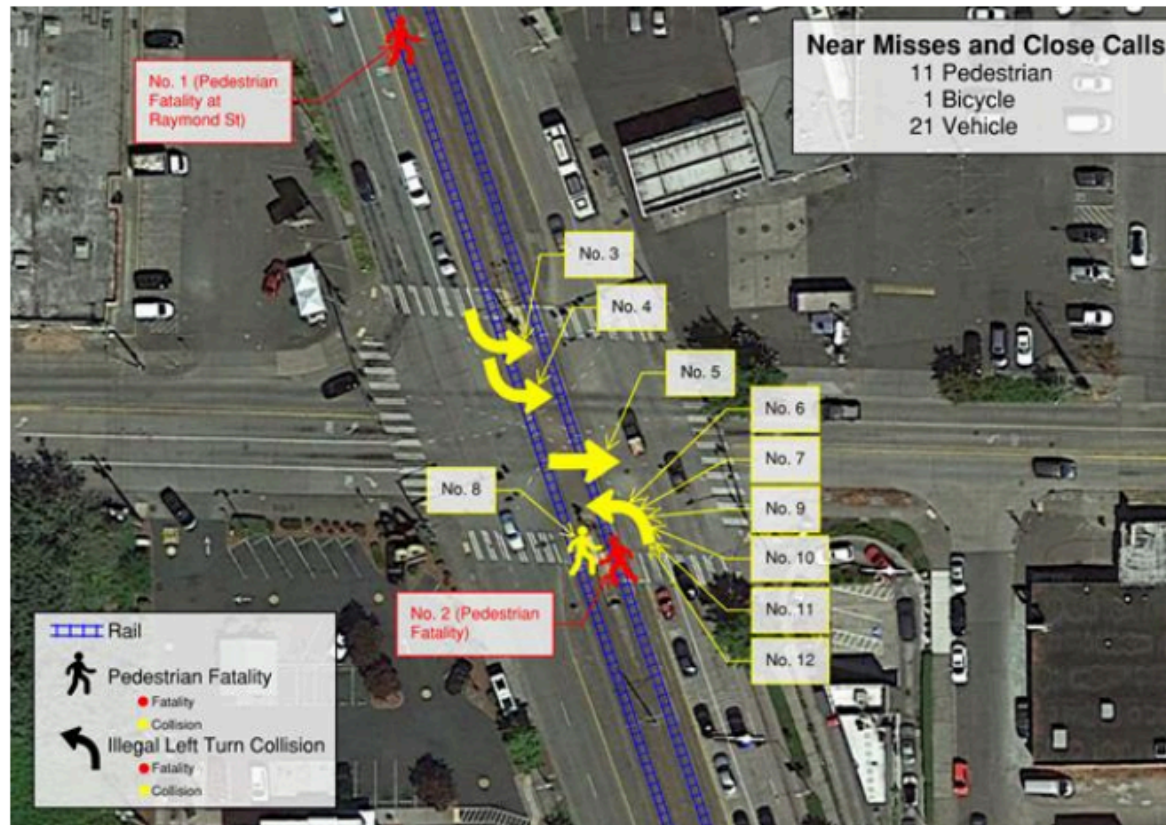


Image: Aerial Google Earth 2020

Event

Event No.	Event Type	Event Date	
1	Fatality	1/11/2016 – 5:25 pm	Ped lay
2	Fatality	9/28/2012 – 1:57 pm	Did n
3	Collision	12/23/2020 – 8:37 pm	Failure
4	Collision	12/2/2020 – 6:04 pm	Failure
5	Collision	10/17/2019 – 8:55 am	Failure of train c
6	Collision	4/18/2019 – 5:41 pm	Failure
7	Collision	6/27/2018 – 10:09 am	Failure
8	Collision	9/30/2016 – 7:35 pm	Did not
9	Collision	7/5/2016 – 3:58 pm	Failure
10	Collision	1/2/2016 – 12:30 pm	Failure
11	Collision	5/6/2014 – 4:12 pm	Failure
12	Collision	2/18/2011 – 9:17 pm	Failure
13	Collision	9/25/2010 – 4:37 pm	Unknow

Intersection Details

Traffic Conditions:

- Designated NB/SB left turn lanes
- LED Preemptive Training/Warning sign on signal head in both directions
- Crossing arms not present

Pedestrian Conditions:

Potential Mitigation

- Implementation of ped swinging gates
- Increased pedestrian signage and pavement markings
- Crossing arm installation
- Bigger pedestrian holding area northern

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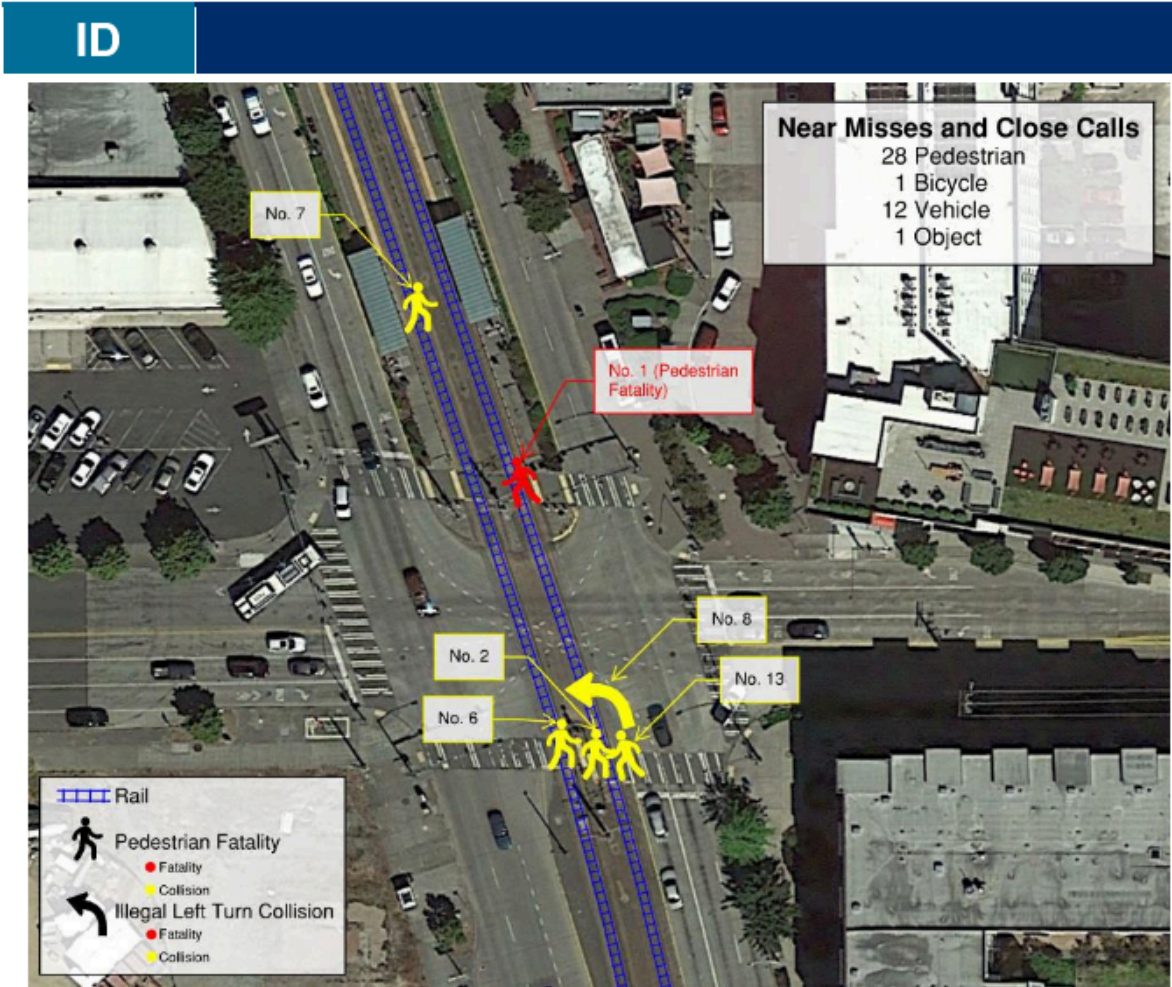


Image: Google Earth 2020

Event			
Event No.	Event Type	Event Date	
1	Fatality	1/23/2017 – 6:45 am	Failure o
2	Collision	5/18/2020 – 5:48 pm	Failure of th
3	Collision	9/27/2019 – 6:45 pm	Unknow
4	Collision	2/9/2019 – 2:06 am	Unknow
5	Collision	1/29/2019 – 6:47 pm	Unknow
6	Collision	6/1/2017 – 10:30 pm	Failure o
7	Collision	10/19/2016- 6:46 pm	Failure of p
8	Collision	12/23/2012 – 10:61 am	Failure o
9	Collision	9/9/2010 – 10:37 am	Unknow
10	Collision	7/8/2010 – 3:30 pm	Unknow
11	Collision	4/23/2010 – 5:40 pm	Unknow
12	Collision	4/2/2010 – 4:20 pm	Unknow
13	Collision	4/24/2009 – 4:15 pm	Failure o



Intersection Details	Potential Mitigation
Traffic Conditions: - Designated NB/SB left turn lanes - LED Preemptive Training Warning sign on signal head in both directions - Crossing arms not present Pedestrian Conditions: - Pedestrian signal present symbolizing TRAIN	- Implementation of ped swinging gates - Increased pedestrian signage and pavement markings - Crossing arm installation - Installation of Z-crossing in northern crossing

Crossing Safety Review

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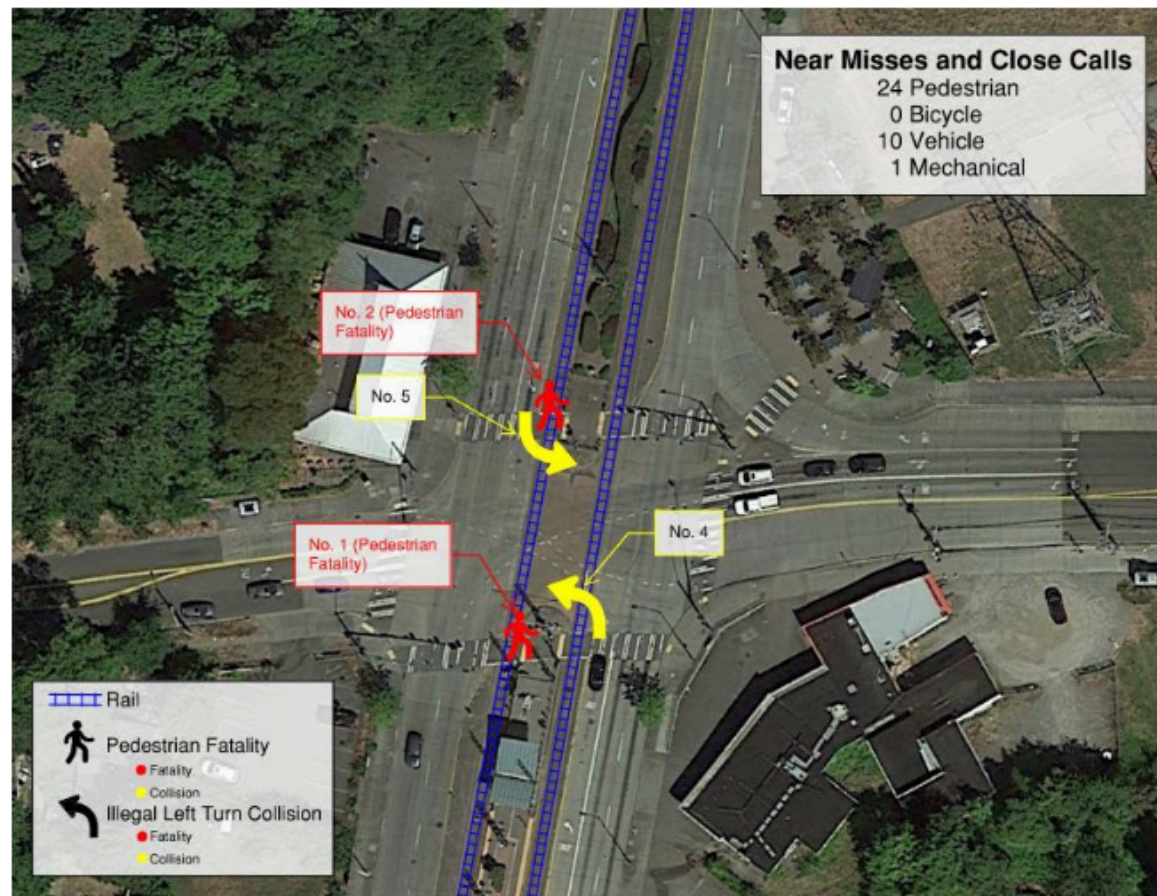


Image: Google Earth 2020

Event

Event No.	Event Type	Event Date	Event
1	Fatality	4/8/2013 – 5:05 pm	Failure o
2	Fatality	5/22/2011 – 12:48 pm	Ped
3	Collision	7/18/2019 – 10:31 pm	Unknow
4	Collision	6/3/2019 – 4:20 pm	Failure o
5	Collision	2/18/2014 – 1:32 pm	Failure o

View of both crossings from the north crossing, facing south
(Field Image taken September 2, 2021)

Intersection Details

Traffic Conditions:

- Designated NB/SB left turn lanes
- LED Preemptive Training Warning sign on signal head in both directions
- Crossing arms not present

Pedestrian Conditions:

- Pedestrian signal present symbolizing TRAIN APPROACHING in the center island facing both directions (both crossings)

Potential Mitigation

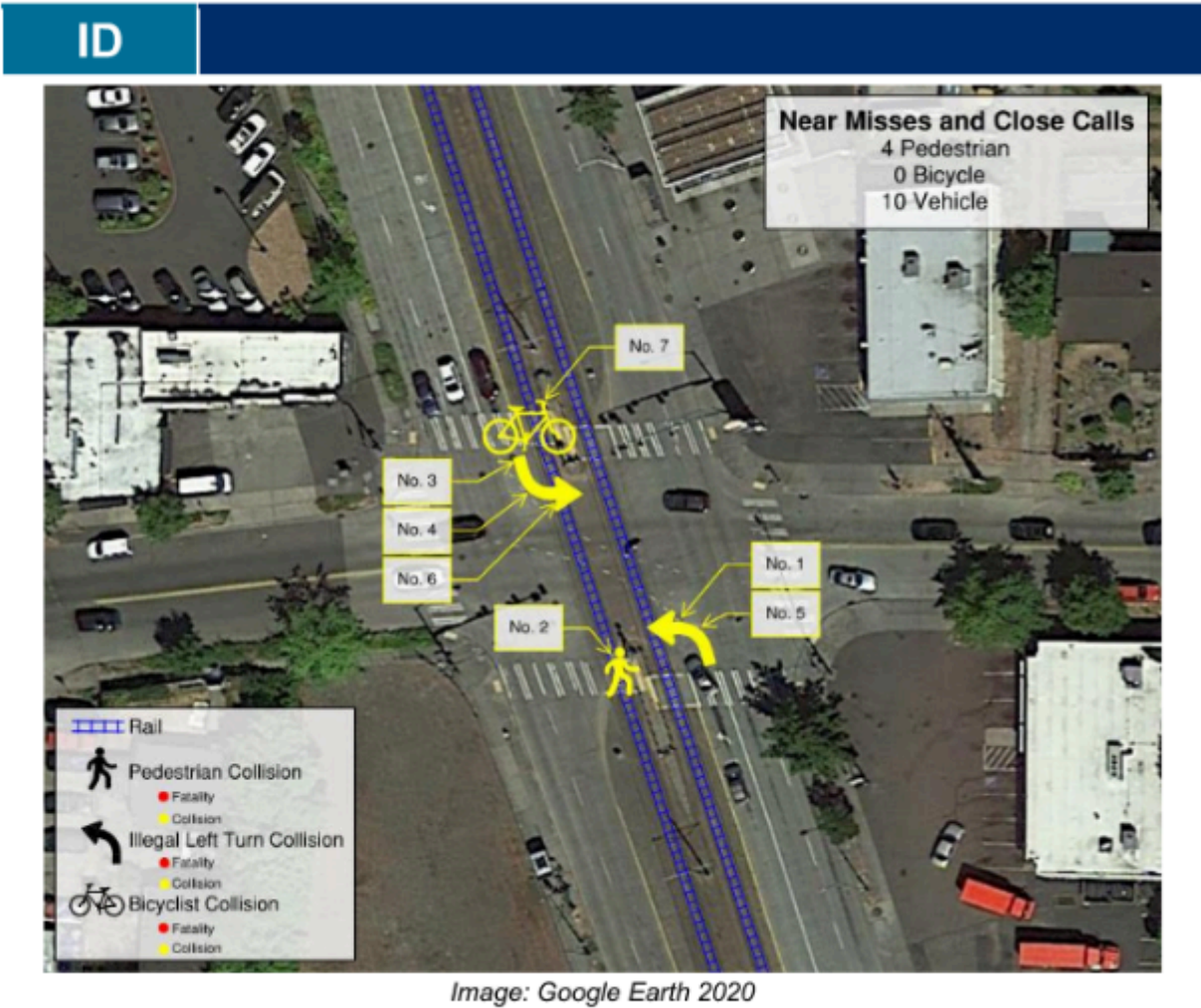
- Implementation of ped swinging gates
- Increased pedestrian signage and pavement markings
- Crossing arm installation
- Installation of Z-crossing
- Dynamic Train Envelop Pavement Markings
- Rail safety ambassadors
 - In pavement lighting



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Crossing Safety Review



Event			
Event No.	Event Type	Event Date	
1	Collision	5/7/2019 – 7:20 pm	Failure at intersection
2	Collision	3/13/2019 – 6:00 pm	Pedestrian
3	Collision	12/27/2018 – 8:55 pm	Failure
4	Collision	8/27/2017 – 9:20 pm	Failure
5	Collision	7/1/2017 – 5:00 pm	Failure
6	Collision	4/24/2017 – 7:50 am	Failure
7	Collision	9/16/2012 – 6:48 pm	Failure



Intersection Details	Potential Mitigation
Traffic Conditions: - Designated NB/SB left turn lanes - LED Preemptive Training Warning sign on signal head in both directions - Crossing arms not present Pedestrian Conditions: - Pedestrian signal present symbolizing TRAIN APPROACHING in the center island facing both directions (both crossings)	- Implementation of ped swinging gates - Increased pedestrian signage and pavement markings - Bigger pedestrian holding area - Crossing arm installation - In pavement lighting

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Crossing Safety Review

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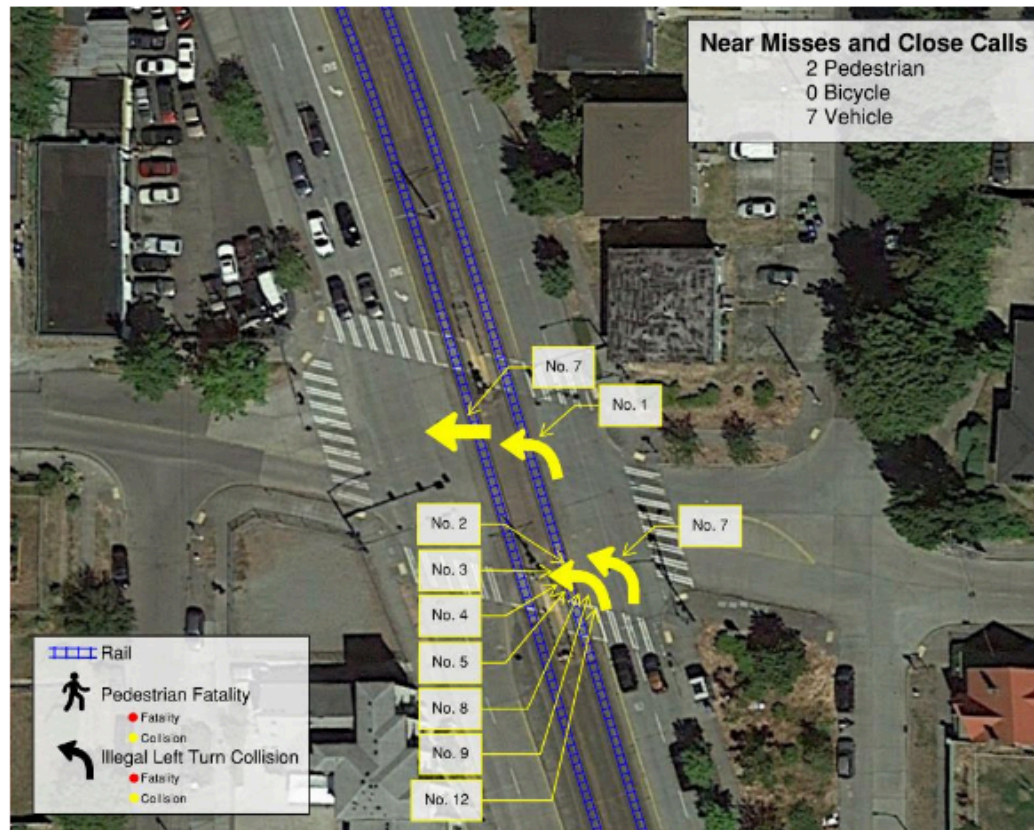


Image: Google Earth 2020

Event			
Event No.	Event Type	Event Date	
1	Collision	9/20/2019 – 4:58 pm	Failure
2	Collision	6/19/2018 – 10:18 am	Failure of the
3	Collision	12/25/2017 – 7:51 pm	Failure of the road n
4	Collision	5/24/2017 – 3:35 pm	Failure
5	Collision	10/5/2015 – 5:59 pm	Failure of the road n
6	Collision	7/3/2015 – 4:02 pm	Failure
7	Collision	2/13/2015 – 6:27 pm	Failure of the road n
8	Collision	9/23/2012 – 5:18 pm	Failure of the road n
9	Collision	11/1/2011 – 10:57 am	Failure of the road n
10	Collision	8/3/2010 – 11:45 am	Unknown
11	Collision	9/15/2009 – 1:35 pm	Unknown
12	Collision	4/15/2009 – 5:08 pm	Failure of the road n

Intersection Details

Traffic Conditions:

- Designated left turn lane
- No LED Preemptive Training Warning sign on signal head in both directions
- Crossing arms not present

Pedestrian Conditions:

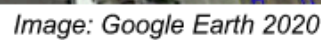
- Pedestrian signal present symbolizing TRAIN APPROACHING in the center island facing both directions (both crossings)
- Z-crossing present (both crossings)

Potential Mitigation

- Consider use of in-street LEDs proposed by ST Safety
- Consider the use of a LED no left turn sign
- Consider restriping and placing a permissive left turn from MLK
- Dynamic Train Envelop Pavement Markings



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Intersection Details

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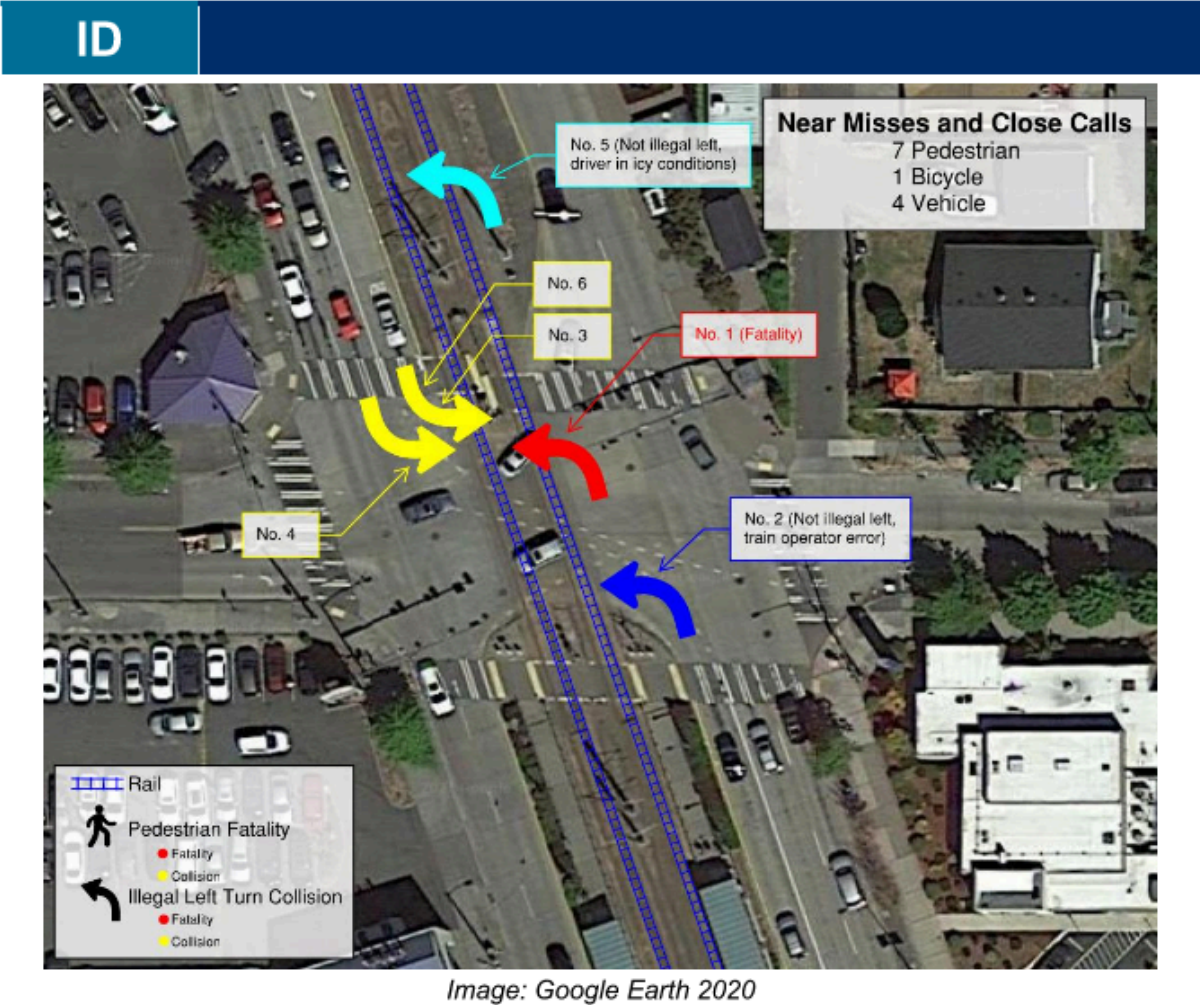
- No designated NB/SB left turn lanes
- No LED Preemptive Training Warning sign on signal head in both directions
- Crossing arms not present

Event			
Event No.	Event Type	Event Date	
1	Collision	1/3/2019 – 6:58 pm	Failure (ignored)
2	Collision	8/1/2014 – 3:21 pm	Failure (ignored)
3	Collision	3/28/2014 – 2:17 pm	Failure (ignored)
4	Collision	8/31/2013 – 1:40 pm	Failure (ignored)
5	Collision	11/7/2011 – 7:52 am	Failure (ignored)
6	Collision	2/22/2011 – 12:48 pm	Failure (ignored)

Potential causes:

- Requested larger signs (from driver of illegal left turn)
- Flashing train signal
- Pavement warnings
- Crossing arm installation

Crossing Safety Review



Event			
Event No.	Event Type	Event Date	
1	Collision, Fatality	9/15/2017 – 5:58 pm	Failure of the road n
2	Collision	6/13/2018 – 10:32 pm	Failure of tra
3	Collision	7/21/2016 – 1:20 pm	Failure
4	Collision	4/20/2015 – 11:11 am	Failure of the road n
5	Collision	1/15/2012 – 7:03 pm	Failure
6	Collision	6/29/2009 – 5:17 pm	Failure



Intersection Details	Potential Mitigation
Traffic Conditions: - Designated NB/SB left turn lanes - LED Preemptive Training Warning sign on signal head in both directions - Crossing arms not present Pedestrian Conditions: - Pedestrian signal present symbolizing TRAIN	- Pavement warnings (retroreflective or rumble transverse rumble strips?) - Crossing arm installation - Bigger pedestrian holding area northern crossing - Z-crossing southern crossing

Crossing Safety Review

ID

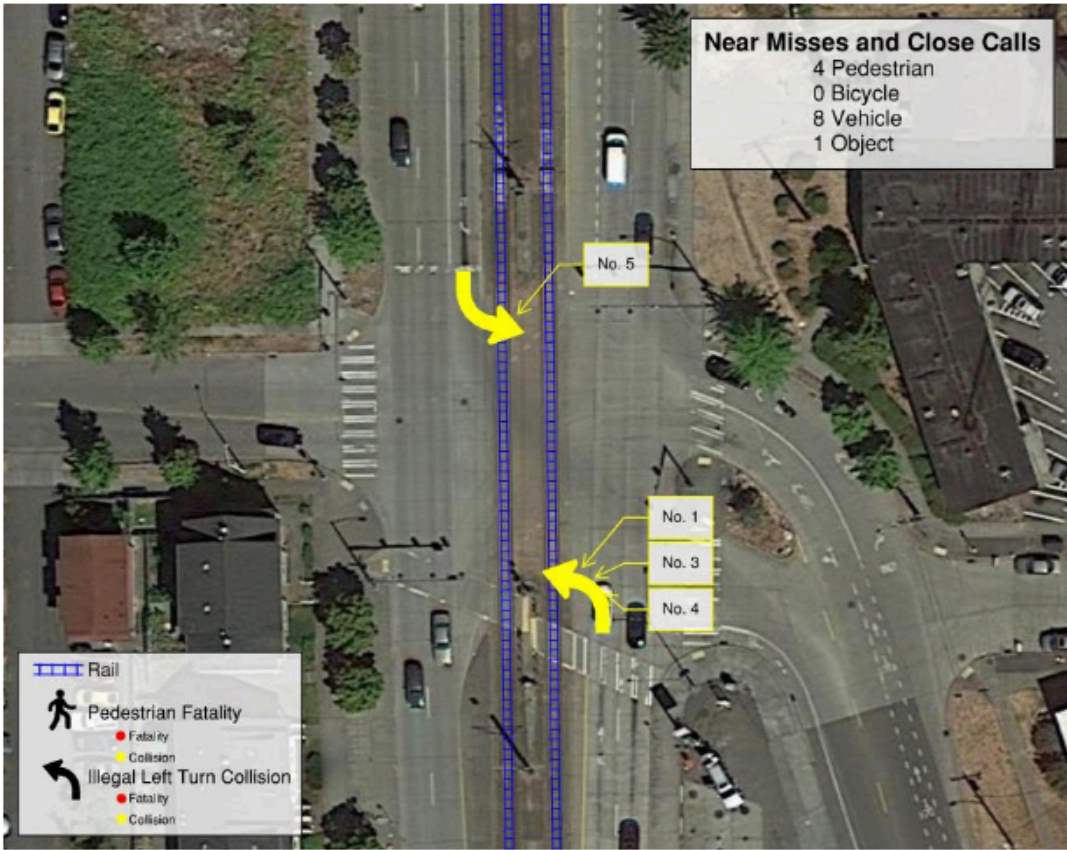


Image: Google Earth 2020

Event Summary

Event No.	Event Type	Event Date	
1	Collision	4/1/2021 – 8:00 am	Failure of the (ignored road m
2	Collision	12/24/2019 – 2:58 pm	Unknown (N
3	Collision	7/29/2019 – 11:48 am	Failure of the (ignored road m
4	Collision	4/9/2019 – 2:20 pm	Failure of the (ignored road m
5	Collision	8/16/2012 – 4:15 pm	Failure of the (ignored road m



Intersection Details

Potential Mitigation

Traffic Conditions:

- Designated SB left turn lane
- LED Preemptive Training Warning sign on signal head in SB directions
- Crossing arms not present

Pedestrian Conditions:

- No north crossing

- Pavement warnings (retroreflective or rumble transverse rumble strips?)
- Crossing arm installation
- Bigger pedestrian holding area southern crossing
- Implementation of ped swinging gates
- Increased pedestrian signage and pavement

Crossing Safety Review

replacement

Crossing Safety Review

ID

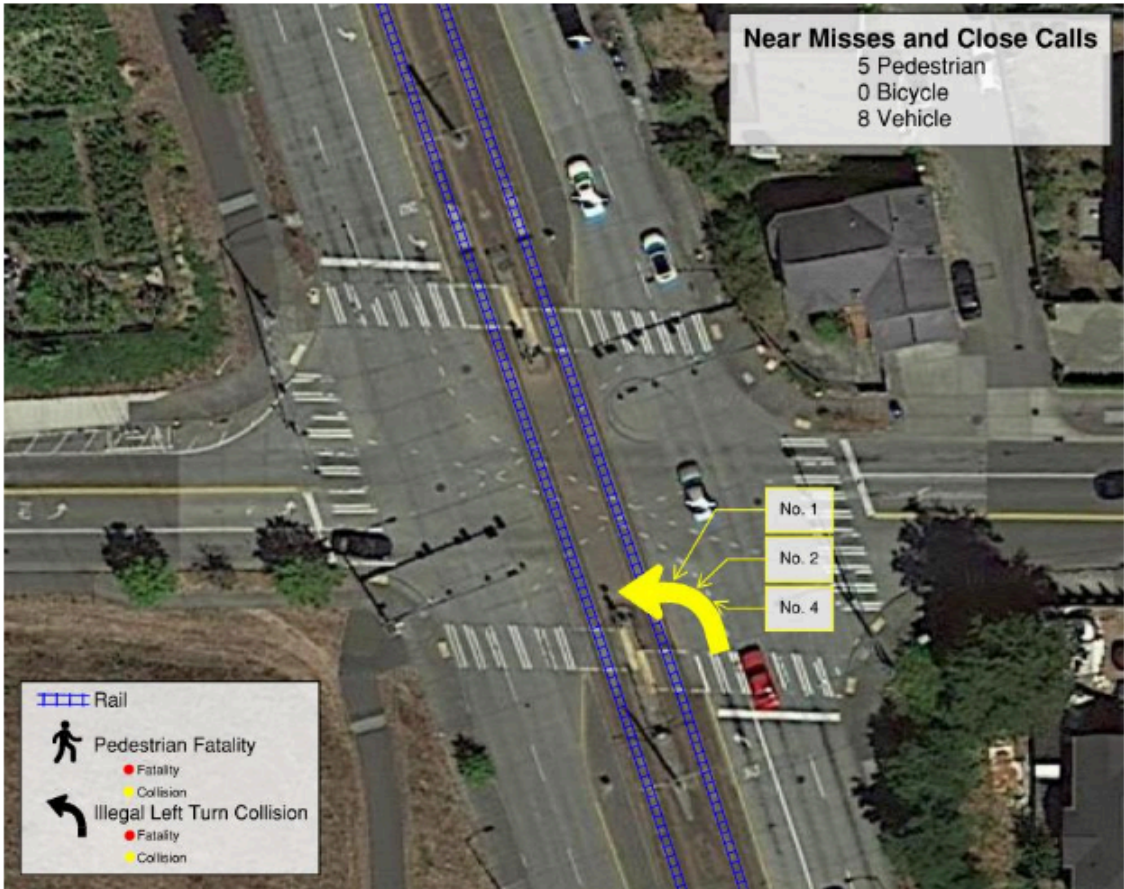


Image: Google Earth 2020

Event			
Event No.	Event Type	Event Date	
1	Collision	5/30/2021 – 12:33 am	Failure
2	Collision	2/21/2021 – 6:56 am	Failure
3	Collision	5/3/2019 – 6:30 pm	Unknown
4	Collision	5/24/2011 – 3:50 pm	Failure



Intersection Details	Potential Mitigation
Traffic Conditions: - Designated NB/SB left turn lanes - LED Preemptive Training Warning sign on signal head in both directions - Crossing arms not present Pedestrian Conditions: - Pedestrian signal present symbolizing TRAIN APPROACHING in the center island facing both	- Pavement warnings (retroreflective or rumble transverse rumble strips?) - Crossing arm installation - Bigger pedestrian holding area - Implementation of ped swinging gates - Increased pedestrian signage and pavement markings

Crossing Safety Review

with

Crossing Safety Review

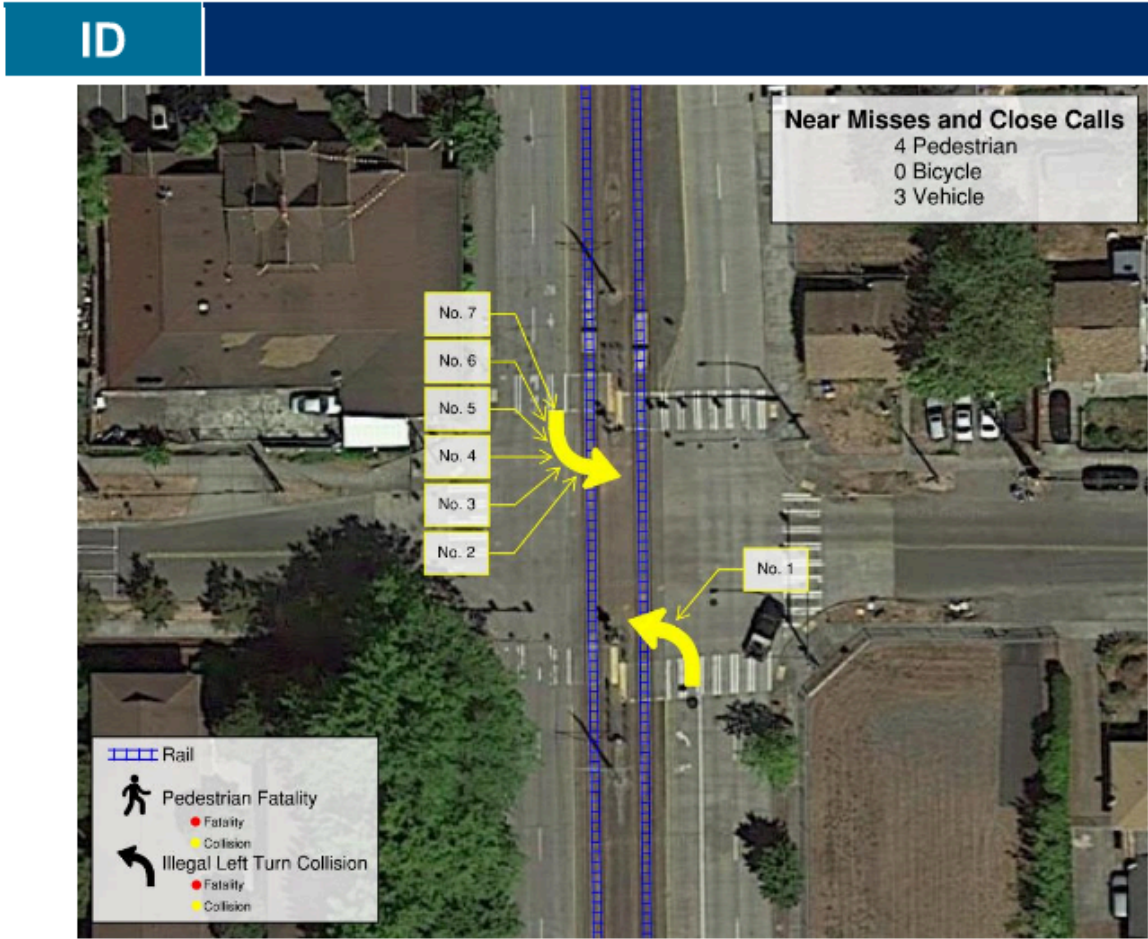


Image: Google Earth 2020

Event			
Event No.	Event Type	Event Date	
1	Collision	4/8/2021 – 9:24 am	Failure
2	Collision	11/7/2020 – 3:05 pm	Failure (ignored)
3	Collision	1/27/2017 – 1:22 pm	Failure (ignored)
4	Collision	12/15/2016 – 9:40 pm	Failure (ignored)
5	Collision	8/16/2016 – 9:58 am	Failure (ignored)
6	Collision	3/10/2010 – 3:15 pm	Failure (ignored)
7	Collision	9/26/2009 – 3:21 pm	Failure (ignored)



Intersection Details	Potential Mitigation
Traffic Conditions: - Designated NB left turn lane - LED Preemptive Training Warning sign on signal head in NB direction - Crossing arms not present Pedestrian Conditions: - Pedestrian signal present symbolizing TRAIN APPROACHING in the center island facing both directions (both crossings) 7 crossing present (both crossings)	- KCM Safety recommends speed reductions through grade crossings along the MLK corridor (outlined in KCM Safety Hazard Analysis of MLK Corridor) - Pavement warnings (retroreflective or rumble transverse rumble strips?) - Crossing arm installation - Bigger pedestrian holding area - Implementation of ped swinging gates - Increased pedestrian signals and pavement

ID

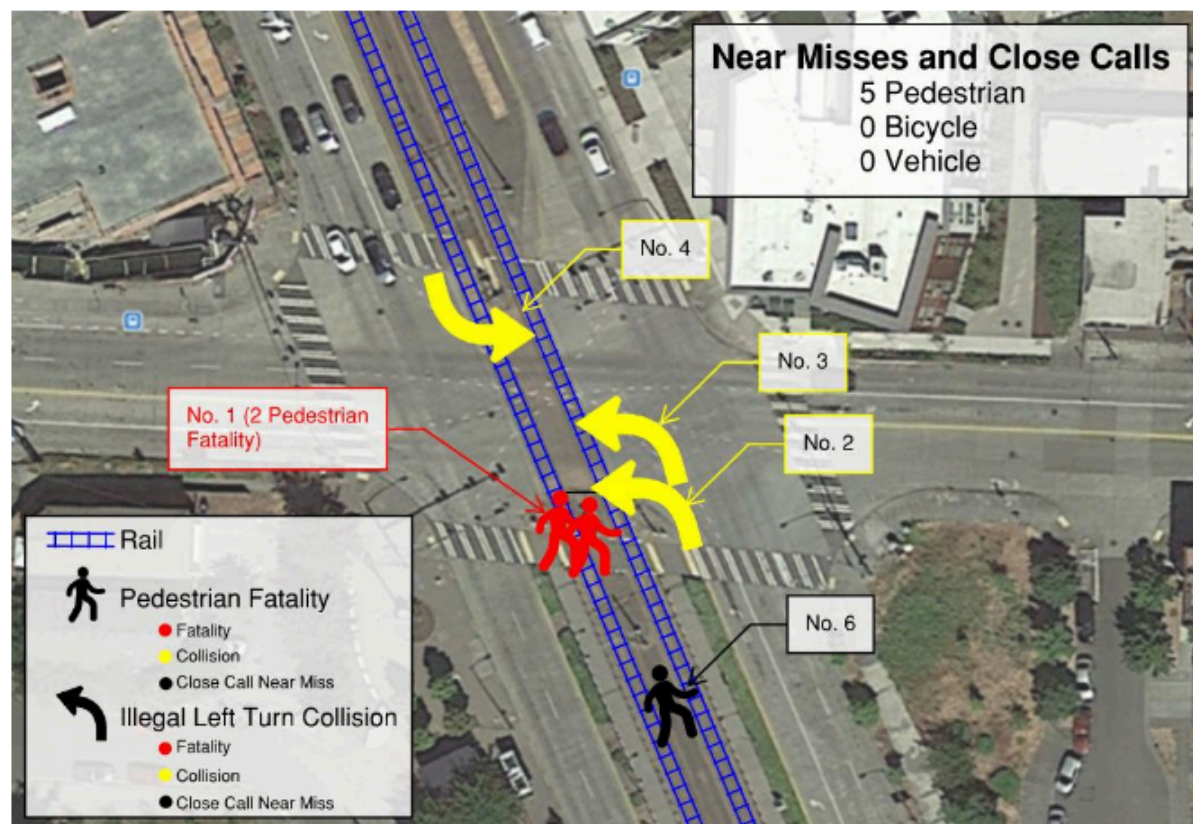


Image: Google Earth 2020

Event			
Event No.	Event Type	Event Date	
1	Fatality	7/2/2021 – 6:22 pm	Did
2	Collision	1/25/2015 – 12:49 pm	Failure
3	Collision	12/11/2014 – 9:40 am	Failure
4	Collision	11/14/2011 – 9:25 am	Failure
5	Near Miss	4/16/2021 – 3:48 pm	M
6	Near Miss	8/30/2019 4:42 pm	Max brak
7	Near Miss	8/16/2018 3:35 pm	Max brak
8	Close Call	7/2/2015	Max bra
9	Close Call	2/13/2014	Unkno



Intersection Details

Potential Mitigation

Traffic Conditions:

- Designated NB/SB left turn lanes
- LED Preemptive Training Warning sign on signal head in NB/SB directions
- Crossing arms not present

Pedestrian Conditions:

- Pedestrian signal present symbolizing TRAIN

- Directional speakers to enhance audible warning
- Full volume warning bells
- Safety barriers
- Gate installation to prevent illegal left turns
- Install LED no-turn lights with the word "train" to operate in synch with the no turn traffic arrow

6 POTENTIAL MITIGATION STRATEGIES

6.1 Mitigation Options

A range of potential mitigation strategies were identified from review of the safety data, field observations, and past studies. The following strategies have potential to improve light rail safety at grade crossings in the MLK corridor.

6.1.1 Pedestrian Signs and Pavement Marking

Increase use of train warning sign (static and dynamic) and pavement markings at rail crossing conflict points at all intersections.

6.1.2 Pedestrian Swing Gates

At intersections with higher pedestrian collision and activity, such as Graham St., Othello St. and Henderson St. install pedestrian entry/exit swing gates to increase pedestrian awareness of conflict areas.

6.1.3 Z Crossings

Z crossings are used at many locations in the Sound Transit system already. They encourage a change in pedestrian direction to increase awareness that they are approaching a conflict area and orient pedestrians in the direction of approaching trains increase likelihood that they will see approaching trains.

6.1.4 Dynamic Train Envelope Pavement Markings

The light rail/street crossings along MLK appear to originally have been constructed with a colorized pavement material to distinguish the dynamic envelope from the surrounding street. However, it appears that over time this has faded considerably, and the contrast is not very apparent anymore. ST should consider having the dynamic envelope pavement markings reapplied at intersections along the MLK corridor.

6.1.5 LED Signing

Increased use of warning signs with active LED lighting will help increase awareness of train crossing by providing dynamic lighting during crossing events.

6.1.6 Adaptive Transit Preemption Recovery

This strategy using the City intersection signal controller to monitor vehicle delay at traffic movements that are preempted (skipped) during train crossings. Rather than returning to a specific signal phase after each preemption the signal software determines which signal phase has the longest delay and returns to that phase first. It appears the City is already using this

type of system at some intersections. Further refinement of the system may put a higher priority of serving left turns from MLK and pedestrian movement crossing MLK and the tracks may increase safety. The progression of through vehicle traffic on MLK may decrease under a recovery strategy more oriented toward reducing delay for movements crossing the light rail tracks but given the frequency of train preemptions in the corridor, green time for through traffic on MLK should remain adequate.

6.1.7 Bigger Pedestrian Holding Area

Increasing the size of pedestrian holding areas will allow more riders to more comfortably wait for trains to arrive and depart the station. Increase holding areas was also facilitate use for pedestrian swing gates and other active safety measures at station pedestrian crossings.

6.1.8 Internally Illuminated Raised Markings

Internally Illuminated Raised Pavement Markings (IIRPM) use light emitting diodes (LEDs) connected to a controller and power source that illuminate red when a train is approaching and occupying a roadway intersection. The IIRPM's are installed into the roadway surface and protrude slightly above the surface. The active lighting during train intersection crossing is designed to increase automobile driver awareness, especially at night.

6.1.9 Left Turn Gates

A left turn gate for light rail operations is similar to those used in parking garages and is a much smaller than a typical railroad crossing gate application. The gate arm is approximately 10 feet long, and only extends across the left turn lane. The gate mechanism is much smaller than a railroad gate, and there are no counterweights that extend behind the mechanism, so it can fit into a raised median. The majority of intersection in the study area would benefit from left turn gates, especially Dawson St., Graham St., Kenyon St. and Othello St.

6.1.10 Pedestrian Crossing Gate System

This builds on the pedestrian swing gates concept by installing a system of crossing gates designed to require pedestrian to enter a safe staging area before entering a conflict point. The gates are actively controlled by the train signal system to prevent entry when a train is actively crossing a conflict area.

6.1.11 Photo Enforcement of Left Turns

The system is similar to the red light and school zone speeding ticket system used by the City of Seattle today. An image is taken of the vehicle and license plate and mailed to the vehicle owner, who then pays, or may contest the infraction. The RCW does allow for use of photo enforcement systems for red light violations and railroad crossings.

6.1.12 Education

This is a unique corridor in the ST system and a targeted safety education campaign in the corridor combined with establishing a safety ambassador program, to have an in-person presence in at stations and intersections is an important safety mitigation strategy. The Link light rail line along MLK has helped foster a variety of changes to the area, as fast, frequent light rail services to other parts of Seattle are now possible. This has encouraged new transit oriented development near the stations, with new apartments, townhomes and condo's near the station. With this growth, residence and travelers to the area may not be familiar with the station and intersection designs, as most other sections of Link are in tunnels or viaducts with grade separated crossings. It may be possible that ST can utilize existing in-house resources for this effort or may need to add additional resources to focus on safety education and outreach.

6.2 Strategy Costs

Planning level cost were developed for the potential mitigation strategies and are shown in Table 3. These costs are developed based upon a general understanding of what type of improvements would be necessary to construct. The costs do not represent a specific intersection location but a generally of what it would cost to implement, construct and oversee the work. The costs shown below are meant to be planning level numbers to compare relative cost of each improvement type to aid in determining improvements that should farther be advanced at each intersection to develop intersection specific costs.

Table 3: Estimated Mitigation Strategy Costs

Estimated Mitigation Strategy Costs					
Item	Unit	Unit Cost	Professional Services ⁽²⁾	Total Cost per Location	Assumptions
Pedestrian Signs and Pavement Markings	EA	\$15,000	\$9,900	\$24,000	Installation at multiple locations
Pedestrian Swing Gates	EA	\$50,000	\$33,000	\$83,000	Installation at multiple locations
Z Crossing	EA	\$100,000	\$66,000	\$166,000	Installation at multiple locations
Dynamic Train Envelope Pavement Markings	EA	\$15,000	\$9,900	\$24,900	Installation at multiple locations
LED Signing	EA	\$50,000	\$33,000	\$83,000	Installation at multiple locations
Adaptive Transit Preemption Recovery	EA	\$25,000	\$16,500	\$41,500	Installation at multiple locations
Bigger Pedestrian Holding Area	EA	\$50,000	\$33,000	\$83,000	Installation at multiple locations
Internally Illuminated Raised Pavement markings	EA	\$160,000	\$105,600	\$265,600	Per Intersection

Left Turn Gate	EA	\$250,000	\$165,000	\$415,000	
Pedestrian Gate System	EA	\$1,500,000	\$990,000	\$2,490,000	Cost may vary based on number and type installed

Sources: Left Turn Gate Cost Estimate provided by LA Metro 10/25/21
IIRPM Costs provided by manufacturer.

(1) Note 1 - EA = Each Location

(2) Note 2 – Professional Services includes costs for agency administration, final design, environmental review, permitting, third party, design services during construction, construction management costs, and contingency

7 TRAIN OPERATING SPEED REVIEW

King County Metro Transit conducted hazard analysis and risk assessment in October 2019 of the MLK grade crossings. One of the recommendations of the assessment was to reduce the speed of light rail trains on MLK from 35 mph to 25 mph. As part of this safety analysis, the DEA Team examined the impact of the same speed reduction between the North study areas boundary, Dakota St., and the south study area boundary, Henderson St.

7.1 Estimated Travel Time Impact

The change in speed from 35 mph to 25 mph means that it takes 41 seconds longer to travel each mile. This change will have implications for LINK operations, as each crew and vehicle will take longer to travel over the route. If there is enough excess layover time at the end of the route, then this increase could be absorbed into the overall operations. However, if there is not any excess then additional vehicles and crew would be needed to maintain the headways and service specified by Sound Transit.

As shown in **Table 4**, the increased running times were estimated by each segment in the corridor, with stations at the key time points. S. Henderson St. corresponds approximately with the north side of the Rainier Beach Station. It was estimated that the approximate increase in running times that would result from a decrease in speed from 35 mph to 25 mph would be 2 minutes and 27 seconds per train.

Table 4: Estimated Train Travel Time Change

Estimated Travel Time increase at 25 MPH	Study Area Start			Study Area End	Totals in Seconds
	Dakota St.	Columbia City Station	Othello Station	Henderson St.	
Sound Transit Mile Posts	2.1	2.6	4.2	5.2	
Increased Travel Time in Seconds:	0	20.5	65.6	41	127.1
Assumption for accel/deceleration		5	10	5	20

Estimated Travel Time increase at 25 MPH	Study Area Start			Study Area End	Totals in Seconds
	Dakota St.	Columbia City Station	Othello Station	Henderson St.	
Approximate Total increase in Travel Time in Seconds	0	25.5	75.6	46	147.1

SOURCE: DEA 10-28-21.

7.2 Operational Impacts

(This section needs some additional information from Sound Transit to be finalized).

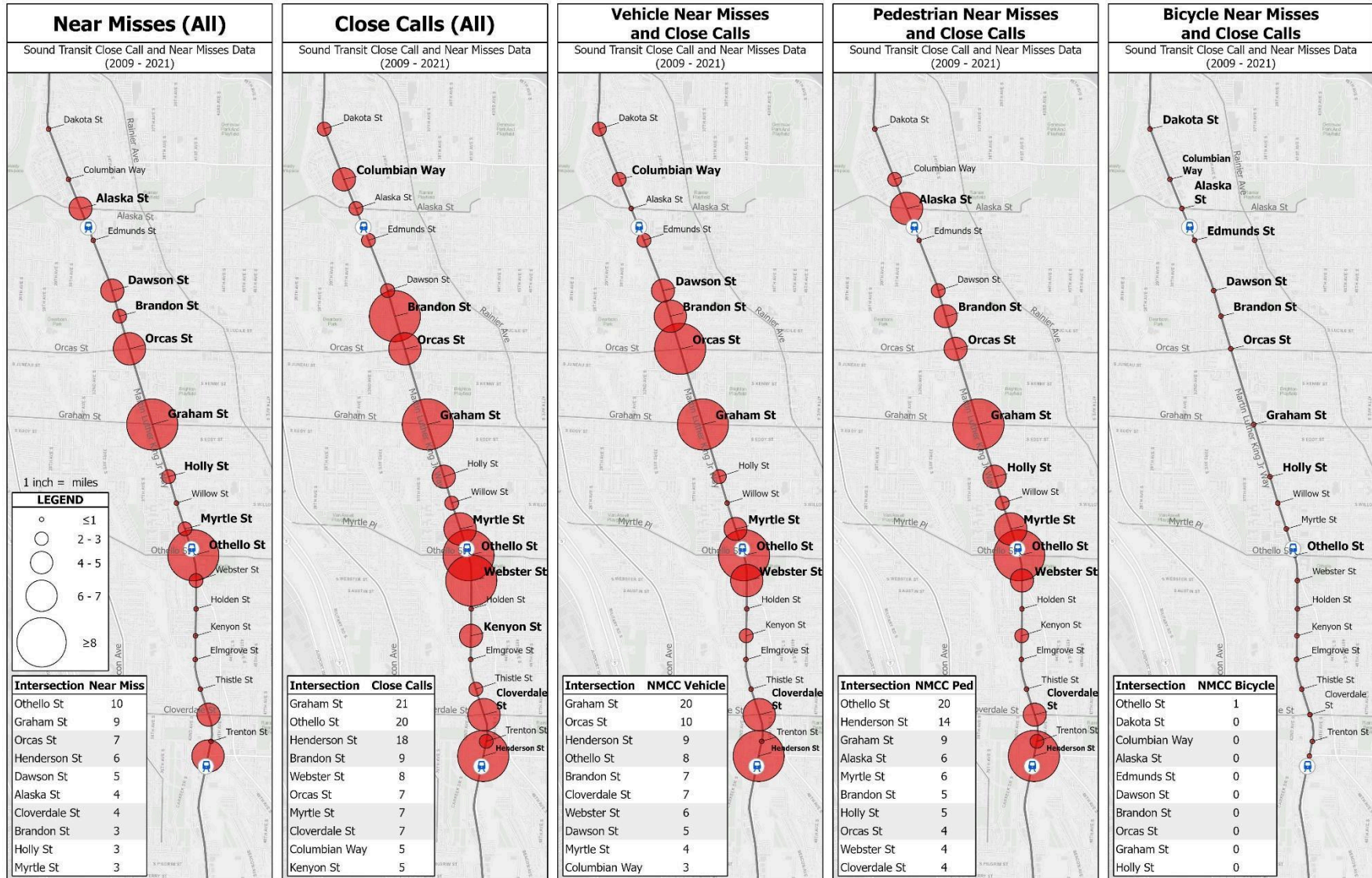
The impact of this increase in running times needs to be analyzed for two elements: rolling stock and light rail operators. Current ST scheduling and operations separate equipment and crew rotations, which means an operator may not stay with a particular light rail train all day, and may change at some point. Sound Transit has minimum times for equipment and operator turns at each end point of their revenue runs (Angle Lake and Northgate). However, there may be excess time above the minimums available for all or part of the day. Furthermore headways, the time between trains, varies between peak periods and non-peak periods, which adds an additional factor to consider in the turn time impacts. If the schedules for both rolling stock and light rail operators can absorb the additional two and a half minute running time at each end point by using this excess, then no additional crews or equipment will be needed.

For example, in the initial review of ST's weekday Link light rail schedules, there appear to be operations in the early evening that could absorb the increased travel time without adversely impacting turn times for both trains and crews, especially at Angle Lake station. Weekend Link schedules seem to have more schedule recovery time at the end of each run, with the exception of train turns late evening at Angle Lake station on Saturday, where only 9 minutes is provided.

Appendix A

ST Rail Collisions, Near-misses, and Close Calls





Appendix B

<<Additional appendices to be provided in
final report as needed>>

